YAW RATE MOTION SENSOR

The present invention relates generally to motion sensors, and more particularly, to a two moving proof mass improved yaw rate gyroscope sensor.

Inertial sensors are finding increased application in a variety of fields. A number of different types of inertial sensors exist. As transportation vehicle systems (e.g., roll detection, vehicle dynamics control, global positioning sensors, etc.) become more sophisticated, a need has developed for an expanded selection of sensors to help optimize operation of such vehicle systems.

Though some types of gyro type sensor devices have seen increased attention in recent years, a need still exists for different types of sensors, particularly those having enhanced sensitivity to applications of Coriolis Force, such as is frequently encountered in the detection of yaw. A need also still exists for a gyro type sensor that obviates the need for cross-axis coupling, and thereby improves the signal to noise characteristics of the sensor.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plan view of a sensor in accordance with the present invention;

FIG. **2** is an enlarged plan view of a portion of a driving element of the sensor illustrated in FIG. **1**;

FIG. **3** is an enlarged plan view of a sensing element of the sensor illustrated in FIG. **1**;

FIG. **4** is an enlarged plan view of a balancing electrode portion of the sensor illustrated in FIG. **1**; and

FIG. **5** is an enlarged plan view of a self-test portion of the sensor illustrated in FIG. **1**.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a yaw rate motion sensor **10** that includes a driving element **12** having a first axis for oscillating generally in the direction of the y-axis upon application of a driving voltage. FIG. **2** is an enlarged plan view of a portion of a driving element of the sensor illustrated in FIG. **1**. Referring to FIGS. **1** and **2**, motion sensor **10** includes a driving element **12** configured along the x-axis, (see FIG. **1**). A first mass **18** is preferably stationary for driving, although it may be moveable relative to a second mass, i.e., shuttle mass **20**. Shuttle mass **20** is suspended in order to allow movement, oscillating generally in the direction of the y-axis upon application of a driving voltage. Driving element **12** has a first natural frequency in the direction of the first axis, i.e., the y-axis, and a second natural frequency in the direction of a second axis, shown in FIG. **1** as the x-axis. The second axis is generally perpendicular to the first axis and in the same plane as the first axis. Motion sensor **10** further includes a sensing element **14** for sensing relative differences in capacitance occasioned from the driving element upon application of a Coriolis force induced by an angular rotation. A linkage **16** translates motion from the driving element **12** to the sensing element **14**.

Driving element **12** has a comb drive structure. The first mass **18** (see FIG. **2**) includes a plurality of electrodes **22** as elongated members or fingers. A suspended shuttle mass **20** also has a plurality of elongated members or fingers, i.e., electrodes **24**, that are interdigitatedly disposed relative to the plurality of electrodes **22**. Shuttle mass **20** is suspended by one or a plurality of suspension flexure arms **30**, affording linkage between the driving element **12** and sensing element **14** and the translation of forces therebetween. Flexure arms **30** may be generally straight, angled, or a combination thereof. FIG. **1** illustrates an angled configuration of flexure arms **30** that includes two generally straight portions oriented orthogonal to one another. Moreover, as shown in FIG. **1**, the shuttle mass is generally attached to the sensing element at some point along its length (e.g., toward an end **32**). Preferably, the linkage is such that driving element **12** can undergo an oscillatory vibration in the direction corresponding to the y-axis in FIG. **1** without causing a similar motion or other consequential feedback in sensing element **14**.

FIG. **3** is an enlarged plan view of sensing element **14** of motion sensor **10** illustrated in FIG. **1**. The sensing proof mass or sensing element **14** preferably is disposed in suitable sensing relationship adjacent driving element **12** and includes a suitable sensing electrode configuration. The sensing electrode configuration preferably includes at least one pair of first electrodes **34** and **34**' and a second electrode **36** disposed therebetween generally in a plane defined by the first electrodes (shown in FIG. **1** as the x-y plane, with a z-plane perpendicular to the x-y plane). A plurality of stationary and moving electrodes are depicted in FIG. **1**, the stationary electrodes **34** and **34**' illustrated as fixed along its length (e.g., at its end) by a post structure **38** and a bar **39**. The sensing element preferably includes a sensing mass **40** that is suspended for oscillation generally in the x-axis direction. The sensing mass exhibits a third natural frequency that is generally parallel to the x-axis (see FIG. **1**). The third natural frequency preferably approximates the first natural frequency of driving element **12** and measures a relative difference in the capacitance occasioned from driving element **12** upon application of a Coriolis force induced by an external motion sought to be detected or measured.

Motion sensor **10** also includes connections for associating driving element **12** to sensing element **14**. The connections shown in FIGS. **1**, **4** and **5** are associated with either or both of a balancing portion **42** or a self-test portion **44** of motion sensor **10**. Associated with the connections are biasing portions such as springs **46** and **48**. The ends of the springs **46** and **48** are secured to sensing element **14** and to an underlying substrate by anchors **50**.

Balancing portion **42** includes a plurality of sets of electrodes that are shown in FIG. **4** as having a first electrode **52** and a pair of second electrodes **54** and **54**' movable relative to each other. First electrode **52** is flanked by second electrodes **54** and **54'**, with both of the second electrodes **54** and **54'** being secured (e.g., to a substrate or other underlying surface) at some point along its length by a post **56** and a bar **57**, respectively. The balancing portion may be connected to a power source for frequency tuning and for helping to maintain driving element **12** and sensing element **14** in a predetermined position relative to one another.

FIG. **5** is an enlarged plan view of a self-test portion **44** of the sensor illustrated in FIG. **1**. Self-test portion **44** includes a plurality of sets of electrodes shown as having a first electrode **58** and a pair of second electrodes **60** and **60**' movable relative to each other. First electrode **58** is flanked by each of the second electrodes **60** and **60'**, with both of the second electrodes **60** and **60**' being secured (e.g., to a substrate or other underlying surface) at some point along its length by a post **62** and a bar **63**. Self-test portion **44** may be connected to a power source as desired for testing and a memory for storing values which can be compared with data from the inducement of a predetermined amount of voltage through the self-test portion. A predetermined voltage is applied to post **62** or bar **63** in order to induce a-Coriolis